HPC 4-7 Day Grid Generation and Field Use
An IFPS Science Steering Team (ISST) Position Paper

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<u>Introduction</u> – The IFPS Science Steering Team (ISST) has reviewed HPC's current proposal to create 4-7 day guidance grids for WFO use in IFPS. Their proposal is in response to an original NWS Eastern Region request tasking HPC with the production of such grids. This request primarily stemmed from the concern of decreasing WFO forecaster efficiency and performance during periods of active short-term weather and an ongoing full grid production requirement. To address this concern, it has been proposed that HPC-produced gridded guidance be made available to incorporate directly into the local digital forecast database.

It is the ISST's position that HPC plays an important role in the production of the NDFD. With the relative immaturity of the current digital forecast system – and until a viable verification system is established – it is still unknown how to best blend local and national forecast expertise to efficiently generate accurate and valuable digital forecasts. It is very possible that there may be benefit from 4-7 day grids generated by HPC, thus warranting its evaluation and testing. However, the scientific validity of the proposed methods to generate these grids is of general concern, as is the concept of how, when, and where these grids will be incorporated. This position paper documents an ISST review of HPC's current and proposed contribution to the production of the digital forecast database, presents the ISST's critique of proposed HPC element generation methodologies, and provides a recommendation on how to most effectively evaluate the impact of these grids on the forecast process and system integrity.

<u>HPC's Role in the Digital Forecast Process</u> – HPC's contribution to the production of the NDFD is communicated in several forms.   This includes HPC-WFO chats on 12Planet, coordination by phone, and using manual HPC guidance in the form of text or graphics – especially through the HPC adjusted MOS points (not available for OCONUS WFOs). It is quite possible that WFOs can benefit from the use of HPC generated forecast grids, most notably as a grid populating option and aid to improving forecaster efficiency and performance during critical short-term high-impact weather events, as a valuable collaboration tool and reference point to better ensure spatial consistencies, and as a valuable tool for communicating HPC's extended model forecast guidance evaluation. To help determine the impact of this information on the digital forecast process, and to subsequently make any needed modifications, a thorough test and evaluation – both objective and subjective – must take place.   The capability to provide OCONUS WFOs with similar guidance – even if in the form of point information – as well as for WFOs with marine responsibilities, must be established in parallel to this effort.

The practice of effective grid production management in the WFO must be considered when addressing decreasing forecaster efficiency and performance during periods of increased workload. This involves placing higher priority on the most active forecast periods (i.e., "the forecast problem of the day"), whether it be in any portion of the database. Most important is the emphasis on active short-term forecast and warning

operations, which must take priority over expending resources on updating extended forecast grids. This priority system is especially valuable when considering extended model forecast accuracy is generally marginal, and model solutions may oscillate significantly from run-to-run. It is in these situations when forecasters primarily add stability to forecasting services by dampening these run-to-run oscillations, in turn electing to endorse (with minor edits, if any) existing grids rather than starting from scratch and populating entirely with new guidance. This methodology typically produces a forecast that over time trends toward a more accurate solution. Similarly, incorporating HPC guidance into the forecast process – assuming this guidance has also dampened the run-to-run model oscillations – presents an additional option for grid population.

The ISST strongly opposes any system design that bypasses local forecast expertise by directly employing HPC grids in the NDFD days 4-7, or that requires use of these grids during these time periods as the default starting point for forecasters in the WFO. At most, this should be only considered as a default for day 8. Forecast accuracy is more often a result of combining national, larger-scale forecast expertise, tools and data (e.g., ensemble information), with local forecast expertise, tools and data residing in WFOs. This local forecast expertise – including adding value over objective guidance – is especially evident in areas of complex terrain, near coasts and over coastal waters, and the OCONUS. This process, when used in combination with effective WFO grid production management and the availability of HPC forecast information through various formats, is more likely to efficiently produce accurate and valuable digital forecasts. Retaining a single source for official digital forecast information throughout all periods also ensures meteorological temporal consistency (between short and extended periods), and better forecast-to-forecast consistency. Local forecasters also remain more aware of critical extended period weather and its associated uncertainties and potential outcomes, resulting in more effective communication of these events to customers and partners.

Thus under the current system design, HPC gridded forecast information should only be considered additional guidance to the WFO, and not mandatory or superior to other guidance or approaches. Each step in the development of the forecast process must be taken carefully and only with sufficient objectively-derived information to determine optimal benefit.

Element Generation Methods – The current HPC grid generation techniques are considered a reasonable first step in developing an optimal forecast grid generation methodology. Yet, the accuracy of such methods, and their value to the forecast process, are still unknown. Here, the ISST offers their critique of these methods, and accompanied – where appropriate – with recommended alternative grid generation methods. (Not all elements produced by HPC will be discussed. For a complete list of available elements see http://www.hpc.ncep.noaa.gov/5km_grids/5km_gridsbody.html)

It must first be understood that HPC has no tool or method by which to directly edit or manipulate 5-km forecast grids similar to what is available in the WFO. Thus HPC forecasters must use N-AWIPS to edit MOS points, and then convert this information to a 5-km grid using techniques described below. The ISST recommends that, in order to more effectively convey HPC forecast information in gridded form, implementing a grid editing capability similar to that at a WFO be explored.

The specific HPC MOS text bulletins used to generate these grids should continue to be provided to WFOs for possible local incorporation using available GFE tools such as "MatchGuidance" (See description available at the Smart Tool Repository at http://www.mdl.nws.noaa.gov/~applications/STR/index.php). The HPC MOS adjusted points should be supplemented with a corresponding list of stations modified by the HPC forecaster, and their associated HPC-MOS deltas.

Although the HPC medium range grids cover all NDFD required 4-7 day period sensible weather elements except wave height, the ISST is concerned that these grids are not accompanied with a 4 dimensional depiction of the meteorology as most other gridded guidance (e.g., GFS, DGEX). Thus, the limited nature of these grids could make it more challenging for the forecaster to assess their quality and to gain insight into the four-dimensional processes envisioned by HPC. This emphasizes the importance of making sure as much consistency as possible exists between these 4-7 days grids and other HPC products available in text or graphical form.

Maximum/Minimum Temperature and Dewpoint - Incorporating climatology information in forecast grid production has been long supported by the ISST. HPC's proposed methodology to use gridded PRISM data to generate Max/Min temperature and dewpoint grids is an important first step toward accomplishing this necessary component of digital forecasting. However, the proposed method to produce the final 5-km MaxT/MinT grids has one important potential deficiency. The current method to create maximum and minimum temperature grids takes ~380 MOS points – any of which may be adjusted by HPC – and spreads HPC-PRISM deltas at these points across all PRISM grid points mapped to the 5-km grid using a Barnes objective analysis technique. Although there are weather regimes and geographic areas whereby this may provide an accurate first guess forecast, inaccuracies can arise when this method is applied to areas of complex terrain, and when weather deviates from climatology. For example, applying an HPC-PRISM delta derived at Salt Lake City (SLC, elevation 4200 feet) to Alta (9800 feet) – just 37 km from SLC – during wintertime inversions when cold air is trapped in the valleys, can potentially produce highly erroneous maximum and minimum temperature values at Alta.

As an alternative, HPC should employ a point-to-grid method that prevents spreading the effects of point values through terrain features. As an example, the MatchMOSAll and MatchObsAll routines (see the Smart Tool Repository) at, which are commonly used in the WFO, start with a background field and randomly distributed point data (e.g., MOS or observations) to create a grid by applying a serpentine fit to these randomly positioned forecasts or observations. Most importantly, they also incorporate an elevation factor that prevents certain values from spreading through terrain features (e.g., spreading SLC values to Alta). As an additional option, the HPC day 4-7 MOS text message, which is currently disseminated to WFOs, can be incorporated within the WFO using the same "Match…" software run locally.

12-Hour Probability of Precipitation – The PRISM precipitation database is considered the cornerstone of the PRISM system. Unfortunately, it is not available in a form helpful to the generation of PoP grids. HPC alternatively uses GFSXMOS at ~1500 points as a background field, and then applies an HPC-MOS difference to the 5-km grid using a Barnes objective analysis. Again, errors will be most evident in areas of complex terrain

where PoP patterns are heavily influenced by orography, and thus will be ignored using this objective analysis technique. What the HPC PoP does provide, however, is a useful generalized view of precipitation potential – serving to directly communicate HPC's evaluation of extended period model guidance. This is viewed as a good starting point to build on for future PoP grid generation methods used at HPC. These methods could possibly evolve toward a PRISM-derived PoP approach, which ultimately could provide a very valuable background PoP field for forecasters.

Wind Speed and Direction – To produce wind information, HPC uses its manually generated medium range pressure/fronts forecasts to calculate the geostrophic wind. Surface wind patterns can be highly ageostrophic, especially in areas of complex terrain. HPC's final step applies wind speed checks using GFSXMOS 12-hr maximum sustained wind speed at ~380 points, and then spreads these values to other grid points using the same Barnes objective analysis. This may unnecessarily dampen winds across peaks, or conversely over predict wind speeds in valleys during a variety of situations. It is paramount that the field be provided tools to take these HPC wind grids and, when deemed necessary by the WFO forecaster, and applies local corrections to account for terrain ageostrophic effects, or local forecast knowledge. Another option is to provide HPC the capability to use DGEX winds, though this may require some form of grid editing software.

Weather Type – HPC's proposed method creates weather from the PoP, MaxT (at 00Z) and MinT (at 12Z) grids. Again, problems arise when employing this method in areas of complex terrain, during shallow inversions whereby a surface temperature below freezing will likely produce freezing rain or ice instead of snow, or with shallow warm layers that still allow for snow at the surface. Inaccurate weather type forecasts can potentially be created in these situations, even beyond the method used to produce the 5-km maximum and minimum temperature grids. Much like what is done in the WFO, this grid generation method should employ the use of vertical model information and snow levels, ideally through various proven methods used in the field (e.g., use of the snow level tool that provides the option to use such fields as 700 mb temperatures, or 1000-500 mb thickness) – some of which might be better applied to HPC grids within the local WFO grid editing environment.

Verification and Field Evaluation – The HPC grids and proposed methodologies should be thoroughly tested and evaluated to examine their impacts on the forecast process and – most importantly – forecast accuracy and system integrity. This should be standard practice when introducing new technology or information into the evolving forecast process. Such testing helps identify areas of the process that need improvement, including necessary modifications to how such HPC grids are generated, or in simply determining the most optimal way to incorporate HPC's extended forecast evaluation and information into the digital forecast process.

The recent DGEX test, evaluation, and implementation exercise can serve as an implementation template for the introduction of new model or national center guidance into the digital forecast process. In this test, EMC conducted objective verification, while a subjective model evaluation, including evaluating its impact on the forecast process, was obtained from a subset of field sites. A similar effort should be undertaken to verify

and evaluate HPC 4-7 day grid generation methods, field use, and impact on local forecast process and operations. This test should be conducted over a minimal period of 60 days – preferably a 90 day test period – and during a period of typically active weather when the use of this guidance can be most valuable and the generation methods truly tested.

Since the current system prevents any method to objectively ensure consistencies between forecast information conveyed in the HPC forecast grids, and HPC text and graphic products, this evaluation effort should also include subjectively evaluating the impact of possible discrepancies in these forecasts on the WFO forecast process.

It is critical to understand the performance and quality of the HPC guidance grids across the entire grid domain and not just at the ~380 MOS points that HPC may potentially modify. This is especially true in areas of complex terrain and coastal regions. This is necessary in order to attempt to verify the complete system that produces these grids. This kind of evaluation ideally requires use of a gridded Analysis of Record (AOR). Unfortunately, since the AOR effort is only in its very infant design stage, other analysis systems or methods must be used to address this more immediate need. ADAS, a high resolution surface data assimilation system developed and operated by the University of Utah/CIRP, has previously been used for NDFD verification in the western United States and could at least be considered for this effort in the west, which is considered an area to most challenge the HPC grids. Development of a national ADAS, though it has been previously explored, presents resource issues that may be insurmountable.

A second option is to implement the "MatchObsAll" routine currently used by numerous WFOs for local verification efforts and for building observation and forecast trends into products and hourly grids. Despite deficiencies in this method, it does provide a reasonable measure of system accuracy, most notably near the observations used in the analysis.

Even if logistics prevent the use of true grid-to-grid objective verification, any set of point observations that is used should go beyond the ~380 points – even beyond the 1279 set of MOS points used for MDL's NDFD point verification – and include lower order sites such as available in the RAWS network. Regardless, the objective verification method used must be capable of evaluating the system's performance *across* the grid. Furthermore, parallel verification must also be conducted on other available objective grid alternatives, such as DGEX or MDL gridded MOS (to be tested this fall), in order to evaluate the effectiveness of HPC grids compared to these grid populating resources.

Summary – The ISST strongly supports involving the insights and experience of HPC in the digital forecast process and continued development of IFPS. This includes exploring the production and incorporation of HPC 4-7 day grids within the WFO grid generation process. However, the system used to generate these grids, and their impact on the forecast process and system accuracy and integrity, must be thoroughly tested prior to full operational implementation. The ISST also advocates that any such system be reserved only as an option for WFOs producing their digital forecasts. Bypassing WFOs in the extended forecast process would oftentimes create anomalous "jumps" in the forecast database between short (days 1-3) and extended (4-7) forecast periods. Most importantly,

it prevents inclusion of any local forecast knowledge and experience into the generation of the digital forecast over extended forecast periods, and effective communication of critical extended period events to local customers and partners.   This recommendation is made with the understanding that WFOs employ effective grid production management and operational priority systems that stress resource expenditures on critical weather periods.